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mentioned disadvantages of the heretofore-known devices and methods of this general type and which has highly precise, reproducible coupling geometries in the Z-direction with as few individual parts as possible.

With the foregoing and other objects in view there is provided, in accordance with the invention, an electro-optical module, comprising:

- a substrate formed with a mounting surface;
- a receptacle for an optical fiber plug defining a beam path substantially perpendicular to the mounting surface; and
- an integrated component unit mounted on the mounting surface, the component unit comprising an electro-optical component and a lens directly aligned with one another in the beam path between the electro-optical component and the receptacle. It is advantageous, thereby, that it is no longer necessary to provide the mounting surface with aligning structures.

In other words, the objects of the invention are satisfied with an electro-optical module of the type mentioned in the introduction that has a mounting surface free of aligning structures, and wherein the electro-optical component and the lens are aligned directly with one another, forming an integrated component unit that can be assembled on the surface.

From a production engineering standpoint, a substantial advantage of the invention consists in that—apart from conductor tracks and metallizations—the surface of the substrate can remain unstructured and free from depressions. Consequently, the selection of the material for the substrate is not dependent on special structuring properties—such as, for example, in the case of the silicon substrate to be used in accordance with the above-mentioned U.S. Pat. No. 5,337,398. Rather, the substrate (for example, printed circuit board) can be selected in an optimum fashion in accordance with aspects of handling, production engineering and, in particular, costs.

A further substantial advantage of the invention consists in the fact that the surface-mountable component unit formed by the electro-optical component and the lens can be produced and tested in advance in a highly precise fashion. Subsequent assembly, affected by tolerances, of a lens support via an electro-optical component which is to be assembled in advance on the substrate is not required with the novel module. Consequently, both production engineering is simplified and an additional tolerance variable is excluded. The component unit can preferably have metallic surfaces for direct electrical contact with the substrate. The reproducible accuracy in the Z-direction is determined only by the component unit, while the substrate thickness is quite irrelevant in this regard.

In accordance with an added feature of the invention, the receptacle is disposed so as not to touch the component unit, the receptacle making contact with and being connected substantially only to the mounting surface of the substrate. This feature permits an embodiment that is completely free from strain and is scarcely stressed in the case of temperature variations.

In accordance with an additional feature of the invention, there is provided an electronic circuit on a surface of the substrate that is averted from the receptacle. Consequently, an electronic drive circuit (in the state of transmission) or a receiving or amplifying circuit can be arranged very near to the component. The signal paths are thereby shortened, and the vulnerability of the system is reduced.

In accordance with another feature of the invention, a cap is attached directly to the mounting surface of the substrate

for electrically shielding the component unit. This feature is particularly important to further improve the radio-frequency properties and the insensitivity to external disturbances.

In accordance with a concomitant feature of the invention, the substrate forms a part of a rigid-flexible-rigid circuit carrier.

The design engineering is thereby simplified. Mechanical and electrical connections are united by design in the flexible part of the rigid-flexible-rigid circuit carrier.

Other features which are considered as characteristic for the invention are set forth in the appended claims.

Although the invention is illustrated and described herein as embodied in an electro-optical module, it is nevertheless not intended to be limited to the details shown, since various modifications and structural changes may be made therein without departing from the spirit of the invention and within the scope and range of equivalents of the claims.

The construction and method of operation of the invention, however, together with additional objects and advantages thereof will be best understood from the following description of specific embodiments when read in connection with the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a longitudinal section through a module according to the invention;

FIG. 2A is an enlarged plan view of the component unit 20 of FIG. 1;

FIG. 2B is a sectional view of the component unit; and

FIG. 3 is a partial perspective view of the substrate as part of a rigid-flexible-rigid circuit carrier.

#### DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the figures of the drawing in detail and first, particularly, to FIG. 1 thereof, there is seen an electro-optical module with a substrate in the form of a printed circuit board 1. Among other components, the PCB 1 carries on its front flat side (first surface) 2 an electro-optical component 3. Indicated on the rear surface 4 of the substrate 1 are individual electronic components 5, 6 which are interconnected via conductor tracks 7, and are connected to connector pads 8, 9 on the first surface 2 by means of electric bushings (not represented in more detail) through the substrate 1. The connector pads serve to make contact with the electro-optical component 3. A flange 10 of a receptacle 12 is supported on the same surface 2. The flange 10 is formed with a central bore 14 for receiving an optical fiber plug (not illustrated in more detail for reasons of clarity). Upon insertion, the end face of the plug comes to bear against a partition 16 with a central bore 17 which defines an optical path between the electro-optical component 3 and an optical fiber end held centrally in the optical fiber plug. As will become clear from the following, more detailed explanation, the component 3 forms an integral component of a component unit 20 mounted on the surface 2 of the substrate 1.

The top side 22, remote from the substrate, of the component unit 20 is shaped as a lens (compare FIG. 2), which is thus situated in the optical path between the component and the receptacle 12. The surface 2 has the pads 8, 9, and is otherwise not structured mechanically; in particular, it includes no aligning depressions for the component unit 20.

As FIG. 2 shows in plan view (FIG. 2A) and in a sectional representation (FIG. 2B), the component unit 20 is an